Flywheel Development

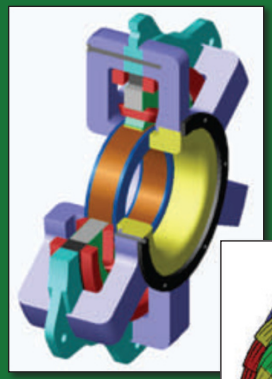
1998—First flywheel module spun to 43,000 rpm

2001—D1 flywheel upgraded and tested to 60,000 rpm
- Capable of repeated test operation between 20,000 and 60,000 rpm at 1000 Watts

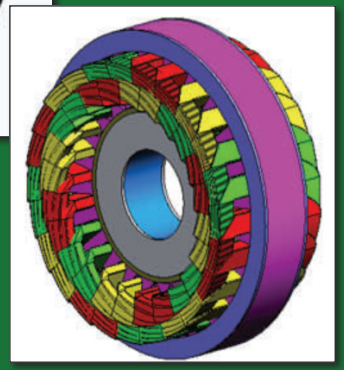
2003—NASA Glenn G2 flywheel designed, fabricated, and tested
- First use of Texas A&M University low-loss magnetic bearing design
- Established world record for flywheel rotor tip speed at 3000 rpm

2004—Demonstrated single-axis integrated power and attitude control for satellite application

2006—NASA Glenn G3 advanced flywheel critical design review completed
- Met near term performance metrics (>25 watt hr/kg system, 85% r/t eff., 90,000 cycles at 75% with DOD)
- High-efficiency NASA motor design high specific energy composite arbor rotor
- Low-loss, redundant magnetic bearings



Glenn G2 comb bearing model



Glenn G3 motor/ generator model

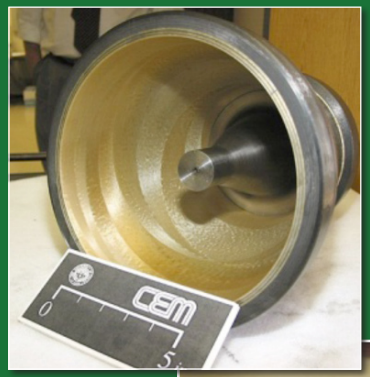
General Information

NASA Glenn Research Center
www.nasa.gov/centers/glenn/home/

Glenn Test Facilities Guide
http://facilities.grc.nasa.gov/documents/facilities_Booklet_2005.pdf

Glenn Research Center Resume
www.nasa.gov/centers/glenn/about/

Business Development and Partnership
http://newbusiness.grc.nasa.gov



Composite arbor

Flywheel energy storage system composite rotor

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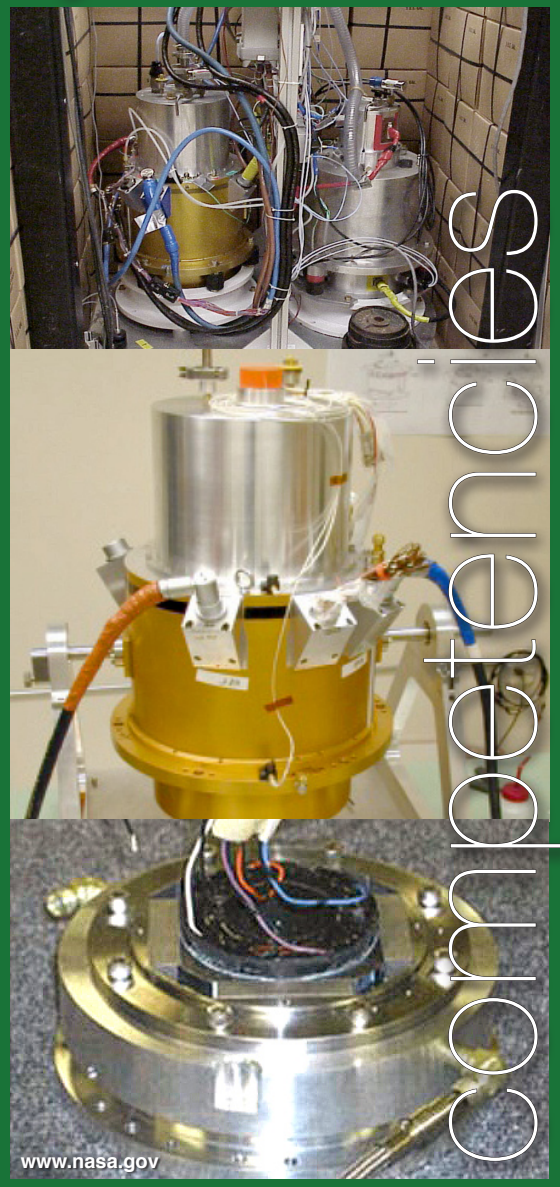
National Aeronautics and Space Administration

Flywheel



Flywheel Competency

Flywheels are becoming an attractive means of storing electrical energy. A nationally recognized design and development team has worked with NASA to develop the next-generation flywheel.

Flywheel Next-Generation Advancements

Rotor system

- All composite rotor system
- Established work record tip speed
- Highest specific energy rotor
- Magnetic bearing systems
- Homopolar magnetic bearing
- Low loss
- Fully redundant

Power Electronics

- Field oriented control
- Synchronous rectification
- High efficiency (98%)

Motor/Generator

- Synchronous permanent magnet
- High efficiency (> 98%)

Safety

- Rotor safe life program
- NDE and life prediction methods
- Life cycle test facility
- Rotor health monitoring system

System

- Integrated power and attitude control

Field-oriented motor generator drive control tested to 60,000 rpm

Flywheel Competencies

Electrical Systems

One objective of this competency is the innovative integration of diverse, state-of-the-art power devices in an optimal configuration for space and terrestrial applications. The appropriate application and control of the various power devices significantly improves overall system performance and efficiency. Advanced power devices include ultra-capacitors and photovoltaics, which have extremely wide potential with applications from nanowatts to megawatts.

Instrumentation and Controls

This advanced research in harsh environment sensors, high power electronics, micro/nano electromechanical systems, high data rate optical instrumentation, and active and intelligent controls to enable self-feeling, self-thinking, self-reconfiguring, and self-healing systems. It is responsible for conducting and directing basic and applied research advanced instrumentation controls technologies for aerospace propulsion and power applications.

Materials

This competency develops processes and characterizes materials for aerospace applications. Metallic, ceramic, and polymeric materials are the current focus, both monolithic and composites. It is possible to enable and extend component durability by understanding, developing, and demonstrating the feasibility and viability of advanced coatings.

Mechancial Components

Component fatigue testing enables the development of advanced materials, processing, and coatings for gears and bearings. Advanced lubrication technology enables high-speed gear systems. Systems testing of advanced components and analytical tool development for condition-based maintenance of mechanical structures is another capability.

Program Management

The ~100 project and program managers at Glenn have experience in managing 119 Centaur rocket launches, the Space Station Freedom power system, Ares launch vehicle systems, as well as numerous electric propulsion, communications, aeropropulsion, and microgravity projects.

Simulation and Modeling

- Design and modeling to identify systems as well as components.
- Virtual reality techniques to support the design of new technologies.
- Simulation of environments to provide testing for systems and components.

Structures Design

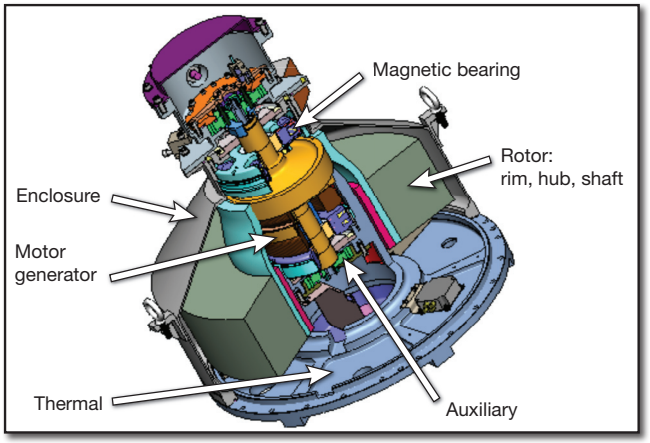
This goal of this competency is to study and model fluid-structures interactions and to predict and verify structural dynamic responses, loads, vibration, and shock environments for aerospace structures.

Systems Analysis

This competency focuses on using tools to analyze aerospace vehicles, propulsion, and power concepts. It is focused on the development and maintenance of systems engineering processes and the applications of engineering processes at a systems level.

Thermal Energy Conversion

This competency focuses on the development of thermal energy at the subsystems and system level as well as verifying the performance of the system.



Flywheel systems: component interaction, space environments, and controls